Original Research Article

Impact of preoperative renal dysfuntion on short-term outcomes of patients undergoing off-pump coronary artery bypass grafting

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Abstract

Aim: To study the incidence and clinical profile of post-operative acute kidney injury in patients undergoing cardiac surgery.
Materials and Methods: The present prospective descriptive study was conducted at a tertiary care hospital in South India, for the period of 2 years (Jan 2017-Dec 2019) to compare post-operative outcomes in patients with normal and varying degrees of non-dialysis dependant renal insufficiency (NRDI) in patients undergoing off pump Coronary Artery Bypass Grafting (OPCABG). All the patients were categorized into five groups/stages by glomerular filtration rate (GFR). All the relevant data was captured for all patients in the study specific case report forms. At the time of admission to the operation baseline clinical characteristics such as age, sex, obesity, smoking, New York Heart Association (NYHA) class, previous myocardial infarction (MI), percutaneous coronary intervention (PCI), diabetes mellitus (DM), hypertension, hyperlipidaemia, chronic obstructive pulmonary disease (COPD), Left ventricular ejection fraction (LVEF), prior CVA, eGFR, serum creatinine, anatomical severity of coronary artery disease (CAD). Operative data like number of grafts, type of conduit, target artery and postoperative details such as major adverse cardiac cerebrovascular events were collected.
Results: Patients in severe group showed higher rates of comorbidities when compared with mild, moderate and normal groups. Mean number of grafts used were similar between the groups (p=0.49). Even though percentage of re-exploration for bleeding did not show any significant difference (p=0.40) among the group, patients in severe group showed high percentage of re-explorations.
Conclusion: There was no significant difference in the patients undergoing off-pump CABG with normal, mild, moderate and severe renal functions in terms of short-term mortality. Off-pump CABG is more reno-protective for patients with normal renal function.

Keywords: CABG, Renal dysfunction, GFR

Introduction

Coronary artery bypass grafting (CABG) is one of the most effective methods for the treatment of multivessel coronary artery disease (CAD) and is a highly successful surgical treatment for the relief of angina prolonging life in patients with coronary artery disease.

ISSN 2515-8260 Volume 09, Issue 03, 2022

Preoperative renal dysfunction is recognized as a significant risk factors that influences the postoperative morbidity and mortality in patients undergoing CABG [1-4].

Elevated preoperative serum creatinine (SCr) is considered an independent risk factor for postoperative morbidity and mortality in patients undergoing cardiac surgery [5-7]. The overall mortality for the patients with preoperative serum creatinine more than 1.5mg/dL, ranges from 5%-30% with the rise in the probability of death [6-9]. So, it is crucial to accurately assess the preoperative renal function. Several studies in literature have revealed preoperative renal dysfunction to be an independent risk factor for CABG surgery [10-12]. Patients with renal dysfunction (RD) who require CABG represent a complex group of patients with accelerated atherosclerosis and advanced cardiovascular disease [13-15].

Serum creatinine is a marker of renal function and its serum level does not usually elevate until the GFR decreases by more than 50% [16-18]. Sajja *et al*. reported that 30% of patients undergoing coronary artery bypass surgery had preoperative normal serum creatinine level, ≤ 1.29 mg/dL and were in stage III of chronic kidney disease by glomerular filtration rate criteria (GFR ≤ 60 ml/min/1.73m2), which indicates that glomerular filtration rate is a more sensitive indicator to detect renal disease early [19].

Mild renal dysfunction is an adverse prognostic indicator in patients with coronary artery disease (CAD) [20]. Several studies showed that patients with mild renal dysfunction have an increased risk of dying within 30 days after coronary surgery [21-23]. Patients with decreased renal function (serum creatinine ≥2.0 mg/dL) carry significant operative risks, require prolonged hospital stays and have a higher risk of dying within 3 years after coronary surgery [23]. In addition, severe preoperative renal disease is associated with a higher incidence of morbidity, need for dialysis, and length of hospital stay after CABG [1].

Coronary artery bypass grafting performed with the aid of cardiopulmonary bypass adversely affects renal function, causing varying degrees of post-operative renal impairment. Off-pump coronary artery bypass grafting (OPCAB), eliminates the need for cardiopulmonary bypass (CPB), has been reported to be associated with better outcomes and is expected to have less negative impact on the postoperative renal function than conventional CABG in patients with renal dysfunction [24-27]. Off-pump coronary artery bypass surgery technique avoids cardiopulmonary bypass circuit induced adverse effects on renal function, multiple other factors cause postoperative renal dysfunction in these group of patients. It is well documented that cardiopulmonary bypass (CPB) initiates a systemic inflammatory response syndrome. This inflammatory response may involve multiple organ systems and cause end-organ injuries, such as the heart, brain, blood, lung, kidney, or gastrointestinal tract [28].

Perioperative renal dysfunction is a significant complication of cardiac surgery, associated with major increases in morbidity and mortality. Acute renal insufficiency is reported to occur after 8% to 30% of cardiac operations performed with CPB [29]. The origin of renal dysfunction is multifactorial, such as the systemic inflammatory response, hypoperfusion, release of endogenous nephrotoxic mediators, use of exogenous nephrotoxic agents, and absence of pulsatile perfusion [30].

Preoperative renal dysfunction, increased age (older than 70 years), prolonged bypass time (longer than 40 min), perioperative hypotension, diabetes, peripheral vascular disease, and postoperative medical complications are the other independent risk factors in the development of renal dysfunction after cardiac surgery [31].

Report from the Society of Thoracic Surgeons National Database on patients undergoing CABG showed that preoperative renal disease is common in patients undergoing CABG and that early mortality and morbidity after CABG rise inversely with declining preoperative renal function. Preoperative renal dysfunction is thus a powerful, independent predictor of postoperative acute kidney injury; hence, the assessment of preoperative renal function should be incorporated into clinical risk assessment and prediction models. Furthermore, the EUROSCORE II includes renal impairment, as measured by creatinine clearance, as one of the risk factors for adverse outcomes after surgery [32].

Although several studies have addressed the effect of lesser degrees of renal impairment on patient's outcomes after on-pump CABG, the effect of normal, mild, moderate and renal impairment together after off-pump coronary artery bypass (OPCAB) has not been well studied. Clinical impression suggests that even mild or moderate elevation of serum creatinine level has an adverse effect on the outcome. Limited information exists on the impact of mild, moderate and severe preoperative renal insufficiency on in hospital and follow-up outcomes after isolated off-pump CABG surgery. Hence, it is necessary to ameliorate the knowledge of incidence, risk factors and outcomes of normal, mild, moderate and severe renal dysfunction in our patients.

Materials and Methods

The present prospective descriptive study was conducted at a tertiary care hospital in South India, and included a total of 888 patients who underwent isolated off-pump CABG during Jan 2017 and Dec 2019. These 888 patients were categorized into five groups by GFR according to National Kidney Foundation guidelines:

- **Stage 1:** Normal renal function (>90 mL/min/1.73m2), 179 patients.
- **Stage 2:** Mild renal insufficiency (60 to 89 mL/min/1.73 m2), 540 patients.
- **Stage 3:** Moderate renal insufficiency (30 to 59mL/min/1.73 m2), 154 patients.
- **Stage 4:** Severe renal insufficiency (15 to 29 mL/min/1.73 m2), 15 patients.
- **Stage 5:** End-stage renal failure (< 15 mL/min/1.73 m2), who were excluded from the study.
- GFR was calculated by using the Modification of Diet in Renal Disease study equation.

Ethical statement

The patients were taken into the study based on inclusion and exclusion criteria. Informed consent was obtained from all the patients and this study was approved by Ethics scientific committee.

Inclusion criteria

1. Patient age 30-80 years old.
2. Patients with Intra-aortic balloon pump (IABP) who were operated off-pump were also included in this study.
3. Patients undergoing primary elective Off-pump CABG.
4. LVEF>30%.
5. Patients who are willing to give consent.

Exclusion criteria

1. Age less than 30 years and more than 80 years.
2. Patient in whom Cardio-pulmonary Bypass was used (On Pump).
3. Patients with End Stage Renal Failure (GFR < 15mL/min/1.73m2).
4. Patients who had developed AKI pre-operatively (48 hours before surgery).
5. Emergency operation.
6. Concomitant cardiac procedures with CABG.
7. Operation which was carried out via an incision other than median sternotomy. (e.g. anterolateral left thoracotomy).
8. Known contraindication to off-pump CABG (e.g. calcified aorta, calcified coronaries and

small target vessels).
9. LVEF<30%.
10. CVA (Recent CVA < 3 months) with or without residual neurological deficit.
11. Patients presenting with aortic dissection.
12. Patients with history of prior renal transplant.
13. Patients who are not willing to give consent.

Sample size calculation

Assuming for a Hypothesised Mean difference among four groups of patients is 25 at 5% significance level with a pooled standard deviation of 18.89 the sample size required to achieve a power of the test 0.90 is calculated using statistical software Minitab (version 19.0).

Off- pump CABG technique (OPCAB)

OPCAB was performed with the Octopus-Evolution tissue stabilizer system device (MEDTRONIC, Cardiovascular, Minneapolis, Minnesota, US) for target coronary artery stabilization. A mean systemic arterial pressure was maintained around 65 to 70 mmHg throughout the procedure. An intracoronary shunt (Medtronic, Inc, Minneapolis, MN, USA) was used in all target coronaries greater than 1.25mm in diameter during construction of distal anastomosis. Humidified carbon dioxide blower /mister (Medtronic, Inc, Grand Rapids, MI) was used to disperse the blood from the anastomotic site while constructing the distal anastomoses.

Data collection

A standard set of data relevant to the study objectives was collected from patient record and case sheets taken from the hospital medical records department. All the relevant data was captured for all patients in the study specific case report forms. At the time of admission to the operation baseline clinical characteristics such as age, sex, obesity, smoking, New York Heart Association (NYHA) class, previous myocardial infarction (MI), percutaneous coronary intervention (PCI), diabetes mellitus (DM), hypertension, hyperlipidaemia, chronic obstructive pulmonary disease (COPD), Left ventricular ejection fraction (LVEF), prior CVA, eGFR, serum creatinine, anatomical severity of coronary artery disease (CAD). Operative data like number of grafts, type of conduit, target artery and postoperative details such as major adverse cardiac cerebrovascular events were collected.

End points

The primary end point is in-hospital mortality from any cause, defined as any death occurring within 30 days of operation. Secondary end points are postoperative renal dysfunction (PRD) and need for postoperative dialysis, myocardial infarction (MI), cerebrovascular accident (CVA), atrial fibrillation during the follow-up period.

Follow–up

Subjects of the study were followed up clinically during the index hospitalization, re-assessment at discharge following surgery.

Statistical methods

All analysis was performed using SAS version 9.2 (SAS institute, Cary, NC) software. Normally distributed continuous variables were compared using a Student t-test, non-normally distributed continuous variables using the Mann-Whitney U test, and categorical variables were compared by $\chi 2$ and Fisher's exact test where appropriate. Estimations of risk and potential independent predictors of outcome were identified by logistic regression analyses. Results were considered statistically significant at a level of p less than 0.05.

Results

The baseline characteristics (table 1) like SM(p=0.06), COPD (p=0.74), LMCA (p=0.87), prior MI (p=0.56), ACE inhibitors (p=0.62), EF (p=0.39), TVD (p=0.76) were similar among the groups. Whereas other baseline characteristics like DM (p=p=<.0001), PVD (p=0.001), prior CVA (p=0.05), NYHA class (p=0.01), means of preoperative serum creatinine (p=<.0001), preoperative IABP (p=0.005) showed statistically significant between the groups. Patients in severe group showed higher rates of comorbidities when compared with mild, moderate and normal groups.
Mean number of grafts used were similar between the groups (p=0.49). Even though percentage of re-exploration for bleeding did not show any significant difference (p=0.40) among the group, patients in severe group showed high percentage of re-explorations.
Postoperative characteristics and outcomes were analysed among the groups (table 2). Postoperative CVA (p=0.67), inotrope usage (p=0.12), Reintubation (p=0.54), postoperative AF (p=0.20), DSWI (p=0.85) and mortality (p=0.17) showed no significant difference between the groups.
Risk of mortality was high in those with severe renal dysfunction [1(6.67)] followed by moderate [3(0.95)], mild [5(0.93)] and normal [1(0.56)]. Highly statistically significant difference was observed with regard to ICU stay (p=<.0001) and hospital stay (p=<.0001) in severe group compared to other groups. Logistic regression revealed that COPD (p=0.04), prior CVA (p=0.002), low EF (p=0.0003) are the predictors of mortality (table 3).

Table 1: Baseline characteristics

Variables	Unit	Normal (n=179)	Mild (n=540)	Moderate (n=154)	Severe (n=15)	P value
Age	Mean ± SD	56.71±8.90	61.84±7.89	63.76±7.87	69.93±5.56	<.0001
Gender	Female	20(11.17)	65(12.04)	16(10.39)	4(26.67)	0.31
	Male	159(88.83)	475(87.96)	138(89.61)	11(73.33)	
DM	No	107(59.78)	225(41.67)	45(29.22)	5(33.33)	<.0001
	Yes	72(40.22)	315(58.33)	109(70.78)	10(66.67)	
HTN	No	65(36.31)	148(27.41)	40(25.97)	3(20.00)	0.08
	Yes	114(63.69)	392(72.59)	114(74.03)	12(80.00)	
SM	No	125(69.83)	415(76.85)	125(81.17)	13(86.67)	0.06
	Yes	54(30.17)	125(23.15)	29(18.83)	2(13.33)	
COPD	No	153(85.47)	450(83.33)	125(81.17)	12(80.00)	0.74
	Yes	26(14.53)	90(16.67)	29(18.83)	3(20.00)	
PVD	No	165(92.18)	481(89.07)	123(79.87)	11(73.33)	0.001
	Yes	14(7.82)	59(10.93)	31(20.13)	4(26.67)	
Prior CVA	No	169(94.41)	506(93.70)	138(89.61)	12(80.00)	0.05
	Yes	10(5.59)	34(6.30)	16(10.39)	3(20.00)	
LMCA	No	129(72.07)	405(75.00)	116(75.32)	11(73.33)	0.87
	Yes	50(27.93)	135(25.00)	38(24.68)	4(26.67)	
Prior MI	No	91(50.84)	290(53.70)	76(49.35)	6(40.00)	0.56
	Yes	88(49.16)	250(46.30)	78(50.65)	9(60.00)	

ACE Inhibitors	No	97(54.19)	320(59.26)	86(55.84)	8(53.33)	0.62
	Yes	82(45.81)	220(40.74)	68(44.16)	7(46.67)	
NYHA Class	No	139(77.65)	413(76.48)	101(65.58)	9(60.00)	0.01
	Yes	40(22.35)	127(23.52)	53(34.42)	6(4.00)	
EF	No	169(94.41)	524(97.04)	148(96.10)	14(93.33)	0.39
	Yes	10(5.54)	16(2.96)	6(3.90)	1(6.67)	
TVD	No	47(26.26)	138(25.56)	34(22.08)	3(20.00)	0.76
	Yes	132(73.74)	402(74.44)	120(77.92)	12(80.00)	
Pre-operative Sr Cr	Mean ± SD	0.85±0.13	1.09±0.24	1.36±0.22	2.48±0.37	<.0001
Preoperative IABP	No	168(93.85)	516(95.56)	138(89.61)	12(80.00)	0.005
	Yes	11(6.15)	24(4.44)	16(10.39)	3(20.00)	

Table 2: Intraoperative and postoperative characteristics

Variables	Unit	Normal (n=179)	Mild (n=540)	Moderate (n=154)	Severe (n=15)	P value
No of grafts	Mean ± SD	3.39±0.77	3.45±0.80	3.48±0.86	3.20±0.94	0.49
Re-exploration for bleeding	No	176(98.32)	532 (98.52)	150(97.40)	14(93.33)	0.40
	Yes	3(1.68)	8(1.48)	4(2.60)	1(6.67)	
Postoperative CVA	No	178(99.44)	533(98.70)	151(98.05)	15(100.00)	0.67
	Yes	1(0.56)	7(1.30)	3(1.95)	0(0.00)	
Inotrope usage	No	172(96.09)	524(97.04)	143(92.86)	14(93.33)	0.12
	Yes	7(3.91)	16(2.96)	11(7.14)	1(6.67)	
Postoperative MI	No	178(99.44)	537(99.44)	152(98.70)	14(93.33)	0.05
	Yes	1(0.56)	3(0.56)	2(1.30)	1(6.67)	
Reintubation	No	176(98.32)	528(97.78)	149(96.75)	14(93.33)	0.54
	Yes	3(1.68)	12(2.22)	5(3.25)	1(6.67)	
Prolonged ventilation	No	170(94.97)	511(94.63)	139(90.26)	11(73.33)	0.002
	Yes	9(5.03)	29(5.37)	15(9.74)	4(26.67)	
Postoperative AF	No	154(86.03)	445(82.41)	120(77.92)	11(73.33)	0.20
	Yes	25(13.97)	95(17.59)	34(22.08)	4(26.67)	
Postoperative Sr Cr	Mean ± SD	1.03±0.14	1.22±0.24	1.54±0.49	3.01±0.96	<.0001
Post-operative AKI	No	141(78.77)	393(72.78)	94(61.04)	9(60.00)	0.002
	Yes	38(21.23)	147(27.22)	60(38.96)	6(40.00)	
Postoperative Dialysis	No	179(100.00)	534(99.44)	150(97.40)	13(86.67)	<.0001
	Yes	0(0.00)	3(0.56)	4(2.60)	2(13.33)	
DSWI	No	178(99.44)	536(99.26)	152(98.70)	15(100.00)	0.85
	Yes	1(0.56)	4(0.74)	2(1.30)	0(0.00)	
ICU stay	No	166(92.74)	506(93.70)	138(89.61)	8(53.33)	<.0001
	Yes	13(7.26)	34(6.30)	16(10.39)	7(46.67)	
Hospital stay	No	171(95.33)	509(94.26)	139(90.26)	10(66.67)	<.0001
	Yes	8(4.47)	31(5.74)	15(9.74)	5(33.33)	
Death	No	178(99.44)	535(99.07)	151(99.05)	14(93.33)	0.17
	Yes	1(0.56)	5(0.93)	3(0.95)	1(6.67)	

Table 3: Logistic regression to find the predictors of mortality

	Estimates	Standard error	Point estimate	95% CI		P value
Age	-0.0069	0.08	0.99	0.83	1.17	0.93
Mean number of grafts	0.62	0.55	1.85	0.62	5.56	0.26
Preoperative serum creatinine	-0.40	1.91	0.67	0.01	28.58	0.83
Sex	0.90	0.65	6.09	0.46	80.89	0.17
Diabetes	-6.19	99.09	<0.01	<0.001	>999.99	0.95
Hypertension	0.36	0.51	2.05	0.27	15.19	0.47

Smoking	-0.42	0.71	0.42	0.02	6.97	0.55
COPD	-1.04	0.52	0.12	0.01	0.98	0.04
PVD	0.11	0.67	1.26	0.08	17.98	0.86
Prior CVA	-1.67	0.56	0.03	0.004	0.31	0.002
Prior MI	-0.21	0.55	0.65	0.07	5.66	0.69
NYHA Class	-0.04	0.53	0.92	0.112	7.56	0.93
EF	-2.11	0.58	0.01	0.001	0.14	0.0003
Preop IABP	-0.76	0.65	0.21	0.016	2.87	0.24
Mild GFR	0.23	1.14	0.24	<0.001	232.08	0.83
Moderate GFR	0.67	0.98	0.37	<0.001	194.99	0.49
Normal GFR	-2.56	1.79	0.01	<0.001	40.97	0.15

Discussion

Preoperative renal dysfunction has been designated as an important risk factor for postoperative outcomes in isolated CABG. Mild renal dysfunction is associated with higher incidence of major adverse cardiovascular and cerebral event (MACCE) as compared to normal population undergoing CABG. Morbidity, resource utilization, in-hospital and long-term mortality are significantly higher with worsening renal dysfunction. The incidences of co-existing morbidities increase with worsening eGFR; as indicated by higher incidences of preoperative stroke, chronic lung disease, insulin dependent diabetes mellitus, peripheral vascular disease, and cerebrovascular disease

The strong association between renal function and outcome after cardiac surgery has been demonstrated in previous studies. Durmaz *et al*. [33] reported increased in-hospital mortality rates of 11.8%, 33.0% and 12.5% in patients who had creatinine levels between 1.6 and 2.5 mg/dl, >2.5 mg/dl respectively.

Weerasinghe *et al*. [9] demonstrated that a mild elevation (1.31-1.5 mg/dl) in preoperative serum creatinine level significantly increased the need for renal replacement therapy, the duration of special care, total postoperative stay and in-hospital mortality.

Various studies have determined the comparison between normal and mild renal dysfunction. Hirose *et al*. studied 1725 patients undergoing CABG and concluded that mild renal dysfunction was associated with prolonged postoperative course and higher incidence of major complications (28.8% vs 10.7%; $p< 0.001$) and mortalities (6.8% vs 0.5%; $p< 0.0005$) [23]. Zaker and colleagues [1] studied 4403 patients undergoing primary isolated CABG with baseline serum creatinine greater than 200umol/l and found significant in hospital mortality (2.1% vs. 6.1%; $p< 0.001$), new dialysis (0.8% vs 5.2%; $p< 0.001$), arrhythmias (29% vs 39%) among the mild renal dysfunction group.

Current study is in concurrence with these studies where the major adverse cardiac and cerebrovascular events are associated in patients with moderate and severe renal dysfunction

Boulton *et al*. in a retrospective review of 14,199 patients undergoing isolated, primary CABG from January 1996 to May 2009 were analysed. They reported that moderate to severe RD or preoperative dialysis was associated with worse adjusted in-hospital mortality: mild RD (odds ratio [OR] 1.42; 95% confidence interval [CI] 0.93 to 2.16; p = not significant); moderate RD (OR 3.55; 95% CI 2.32 to 5.43; $p < 0.05$]; severe RD (OR 8.84; 95% CI 4.92 to 15.9; $p < 0.05$); and dialysis-dependent (OR 9.64; 95% CI 5.45 to 17.0; $p < 0.05$). Adjusted long-term survival was worse across levels of RD. The OPCAB patients with moderate to severe RD had worse long-term survival than on-pump CAB patients; however, the surgery types were similar among normal, mild, and dialysis patients. The current study is in accordance with the published literature in terms of worsening of the morbidity and mortality with the levels of renal dysfunction.

Ueki and colleagues [34] filtration rate (eGFR). The clinical outcomes were compared between patients undergoing off-pump (n= 23,634) and on-pump CABG in each stratum. The study demonstrated that in patients with mildly reduced renal function (eGFR of 60-89 mL/min/1.73 m2), there was no significant risk reduction effect of off-pump CABG for operative mortality. Conversely, in patients with moderate or severe renal disease (eGFR of<60 mL/min/1.73 m 2), off-pump CABG was associated with a significantly lower incidence of operative death. In addition, in patients with severe renal disease (eGFR of <30 mL/min/1.73 m2), off-pump CABG was associated with a significantly lower incidence of de novo dialysis.

Ueki and colleagues concluded that off-pump CABG significantly reduced operative mortality in patients with moderate or severe preoperative renal dysfunction but not in those with mild preoperative renal dysfunction. The present study was conducted in patients who underwent only off-pump CABG and compared mild, moderate, normal and severe preoperative renal dysfunction. Even though the current study was not in alignment with the study design of Ueki *et al*., the results of this study are similar in terms of less outcomes postoperatively may be due to usage of off-pump CABG technique.

Prolonged mechanical ventilation and greater risk of reintubation in patients with renal dysfunction are attributed to impaired ability of the kidneys to eliminate fluid from the interstitium thereby predisposing these patients to fluid retention and excessive lung water. Studies have shown that a need for more than 48hrs ventilation and reintubation is higher in patients with significant renal dysfunction undergoing CABG relative to those with normal or mild renal [35] dysfunction. The authors [35] found greater requirement for ventilation in their study. In the current study also the requirement of mechanical ventilation was more with the worsening of renal dysfunction.

Charytan *et al*. showed progressive increase in ventilation duration in the patients with various stages of CKD [36]. In concurrence with these authors the current study also showed slightly high requirement of ventilation in severe group compared to normal group.

Incidence of post-operative atrial fibrillation (AF) has been seen to increase with progression of CKD. The mechanism behind the myocardial electrical disturbance can be attributed to electrolyte imbalance frequently observed in this subset of patients when compared to patients with normal renal function undergoing CABG. The high incidence of stroke in CKD patients has been shown by studies in plenty [35]. Similarly increase in incidence of postoperative AF and CVA was observed in this study.

Preoperative renal dysfunction is recognized as a risk factor for postoperative morbidity and mortality in patients undergoing CABG [1-4]s, classified by eGFR category are shown in Table 1. Patients with severe RD and preoperative HD had increased incidence of other known preoperative risk factors for coronary artery disease associated with poorer outcomes such as diabetes mellitus (p 0.001), prior stroke (p 0.001), and New York Heart Association class III or IV heart failure (p 0.001). This study showed that COPD (p=0.04), prior CVA (p=0.002), low EF (p=0.0003) are the predictors of mortality.

Limitations

The patient population is small. Data belongs to a single hospital thus the data and results derived may not be generalized to reflect other cardiac surgery centers.

Conclusions

There was no significant difference in the patients undergoing off-pump CABG with normal, mild, moderate and severe renal functions in terms of short-term mortality. Off-pump CABG is more reno-protective for patients with normal renal function but for patients with moderate and severe renal dysfunction may need preoperative assessment of renal function by GFR in addition to serum creatinine levels to stratify the risk for postoperative renal dysfunction and to optimize measures for renal preservation during surgical myocardial revascularization.

References

1. Zakeri R, Freemantle N, Barnett V, *et al*. Relation between mild renal dysfunction and outcomes after coronary artery bypass grafting. Circulation. 2005;112(9):I270-5.
2. Vohra HA, Armstrong LA, Modi A, *et al*. Outcomes following cardiac surgery in patients with preoperative renal dialysis. Interact Cardiovasc Thorac Surg. 2014;18:103-11.
3. Domoto S, Tagusari O, Nakamura Y, *et al*. Preoperative estimated glomerular filtration rate as a significant predictor of long-term outcomes after coronary artery bypass grafting in Japanese patients. Gen Thorac Cardiovasc Surg. 2014;62:95-102.
4. Marui A, Okabayashi H, Komiya T, *et al*. Impact of occult renal impairment on early and late outcomes following coronary artery bypass grafting. Interact Cardiovasc Thorac Surg. 2013;17:638-43.
5. Roques F, Nashef SAM, Micheal P, *et al*. Risk factors and outcome in European cardiac surgery: analysis of the Euro-SCORE multinational database of 19030 patients. Eur. J Cardiothorac Surg. 1999;15:816-23.
6. Lok CE, Austin PC, Wang H, Tu JV. Impact of renal insufficiency on short-and long-term outcomes after cardiac surgery. Am Heart J. 2004;148:430-8.
7. Devbhandari MP, Duncan AJ, Grayson AD, *et al*., On the behalf of the North West quality improvement programme in cardiac interventions. Effect of risk-adjusted, non-dialysis dependent renal dysfunction on mortality and morbidity following coronary artery bypass surgery: a multicenter study. Eur J Cardiothorac Surg. 2006;29:964-70.
8. Wang F, Dupuis JY, Nathan H, Williams K. An analysis of the association between preoperative renal dysfunction and outcome in cardiac surgery. Estimated creatinine clearance or plasma creatinine level as measures of renal function. Chest. 2003;124:1852-62.
9. Weerasinghe A, Hornick P, Smith P, *et al*. Coronary artery bypass grafting in non-dialysis dependent mild to moderate renal dysfunction. J Thorac Cardiovasc Surg. 2001;121:1083-9.
10. Chawla LS, Zhao Y, Lough FC, *et al*. Off-pump versus onpump coronary artery bypass grafting outcomes stratified by preoperative renal function. J Am Soc Nephrol. 2012;23:1389-97.
11. Gallagher S, Kapur A, Lovell MJ, *et al*. Impact of diabetes mellitus and renal insufficiency on 5-year mortality following coronary artery bypass graft surgery: a cohort study of 4869 UK patients. Eur. J Cardiothorac Surg. 2014;45:1075-81.
12. Holzmann MJ, Sartipy U. Relation between preoperative renal dysfunction and cardiovascular events (stroke, myocardial infarction or heart failure or death) within three months of isolated coronary artery bypass grafting. Am J Cardiol. 2013;112:1342-6.
13. Liu JY, Birkmeyer JO, Sanders JH, *et al*. Risks of morbidity and mortality in dialysis patients undergoing coronary artery bypass surgery. Circulation. 2000;102:2973-7.
14. Reddan DN, Szczech L, Tuttle RH, *et al*. Chronic kidney disease, mortality and treatment strategies among patients with clinically significant coronary artery disease. J Am Soc Nephrol. 2003;14:2373-80.
15. Szczech LA, Reddan DN, Owen WF, *et al*. Differential survival following coronary revascularization procedures among patients with renal insufficiency. Kidney Int. 2001;60:292-9.
16. Kellen M, Aronson S, Roizen MF, *et al*. Predictive and diagnostic tests of renal failure: a review. Anesth Analg. 1994;78:134-42.
17. Stevens LA, Coresh J, Greene T, Levey AS. Assessing kidney function-measured and estimated glomerular filtration rate. New Engl. J Med. 2006;354:2473-83.
18. Duncan L, Heathcote J, Djurdjev O, Levin A. Screening for renal disease using serum

creatinine: who are we missing? Nephrol Dial Transplant. 2001;16:1042-6.
19. Sajja LR, Mannam G, Chakravarthi RM, *et al*. Coronary artery bypass grafting with or without cardio pulmonary bypass in patients with preoperative non-dialysis dependent renal insufficiency: a randomized study. J Thorac Cardiovasc Surg. 2007;133:378-88.
20. Anevakar NS, McMurray JJV, Velasquez EJ, *et al*. Relation between renal dysfunction and cardiovascular outcomes after myocardial infarction. N Engl. J Med. 2004;351:1285-1295.
21. Anderson RJ, O'brien M, MaWhinney S, *et al*. Renal failure predisposes patients to adverse outcome after coronary artery bypass surgery. VA Cooperative Study #5. Kidney Int. 1999;55:1057-62.
22. Nakayama Y, Sakata R, Ura M, Itoh T. Long-term results of coronary artery bypass grafting in patients with renal insufficiency. Ann Thorac Surg. 2003;75:496-500.
23. Hirose H, Amano A, Takahashi A, Nagano N. Coronary artery bypass grafting for patients with non-dialysis-dependent renal dysfunction (serum creatinine > or =2.0 mg/dl). Eur J Cardiothorac Surg. 2001;20:565-72.
24. Sajja LR, Mannam G, Chakravarthi RM, *et al*. Impact of preoperative renal dysfunction on outcomes of off-pump coronary artery bypass grafting. Ann Thorac Surg. 2011;92:2161-7.
25. Cooper WA, O'Brien SM, Thourani VH, *et al*. Impact of renal dysfunction on outcomes of coronary artery bypass surgery: Results from the Society of Thoracic Surgeons National Adult Cardiac Database. Circulation. 2006;113:1063-70.
26. Massoudy P, Wagner S, Thielmann M, *et al*. Coronary artery bypass surgery and acute kidney injury: impact of the off-pump technique. Nephrol Dial Transplant. 2008;23:28-530.
27. Seabra VF, Alobaidi S, Balk EM, Poon AH, Jaber BL. Off-pump coronary artery bypass surgery and acute kidney injury: a meta-analysis of randomized controlled trials. Clin J Am Soc. Nephrol. 2010;5:1734-44.
28. Edmunds LH. Why cardiopulmonary bypass makes patients sick. In Advances in Cardiac Surgery; Karp RB, Laks H, Wechsler AS, Eds.; Mosby: St. Louis, 1995, 131-167.
29. Corwin HL, Sprague SM, DeLaria GA, Norusis MJ. Acute renal failure associated with cardiac operations: a case control study. J Thorac. Cardiovasc. Surg. 1989;98(6):1107-1112.
30. Regragui IA, Izzat MB, Birdi I, Lapsley M, Bryan AJ, Angelini GD. Cardiopulmonary bypass perfusion temperature does not influence perioperative renal function. Ann. Thorac. Surg. 1995;60(1):160-164.
31. Zanardo G, Michielon P, Rosi P, Teoori T, Antonucci F, Caenoro G, *et al*. Effects of a continuous diltiazem infusion on renal function during cardiac surgery. J Cardiothorac. Vasc. Anesth. 1993;7(6):711-716.
32. euroSCORE.org. euroSCORE: European System for Cardiac Operative Risk Evaluation. Available at: www.euroscore.org. Accessed March 23, 2018.
33. Durmaz I, Büket S, Atay Y, Yağdi T, Ozbaran M, Boğa M, *et al*. Cardiac surgery with cardiopulmonary bypass in patients with chronic renal failure. J Thorac Cardiovasc Surg. 1999 Aug;118(2):306-15.
34. Ueki C, Miyata H, Motomura N, *et al*. Offpump technique reduces operative mortality after elective coronary artery bypass grafting in patients with preoperative renal failure. J Thorac Cardiovasc Surg. 2018;156:976-83.
35. Boulton BJ, Kilgo P, Guyton RA, *et al*. Impact of preoperative renal dysfunction in patients undergoing off-pump versus on-pump coronary artery bypass. Ann Thorac. Surg. 2011;92:595-602.
36. Charytan DM, Yang SS, McGurk S, Rawn J. Long and short-term outcomes following coronary artery bypass grafting in patients with and without chronic kidney disease. Nephrol. Dial. Transplant. 2010;25(11):3654-3663.